EXHIBIT 29

Engineer Report, Stevens & Koon, Consulting Engineers,
to Cole Harwood, December 1, 1929

ENGINEERING REPORT

STEVENS & KOON

CONSULTING ENGINEERS

PORTLAND OREGON

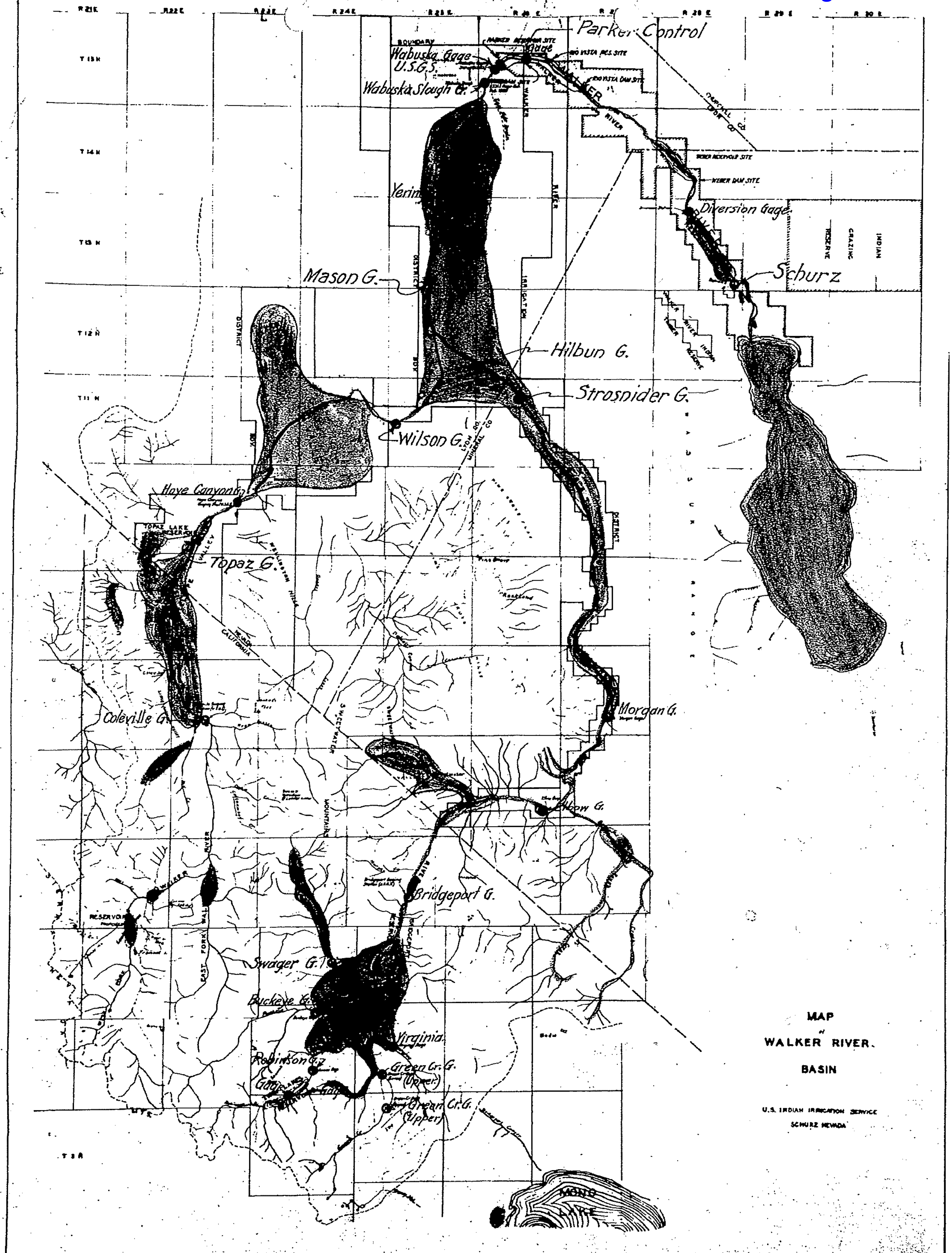
UNITED STATES

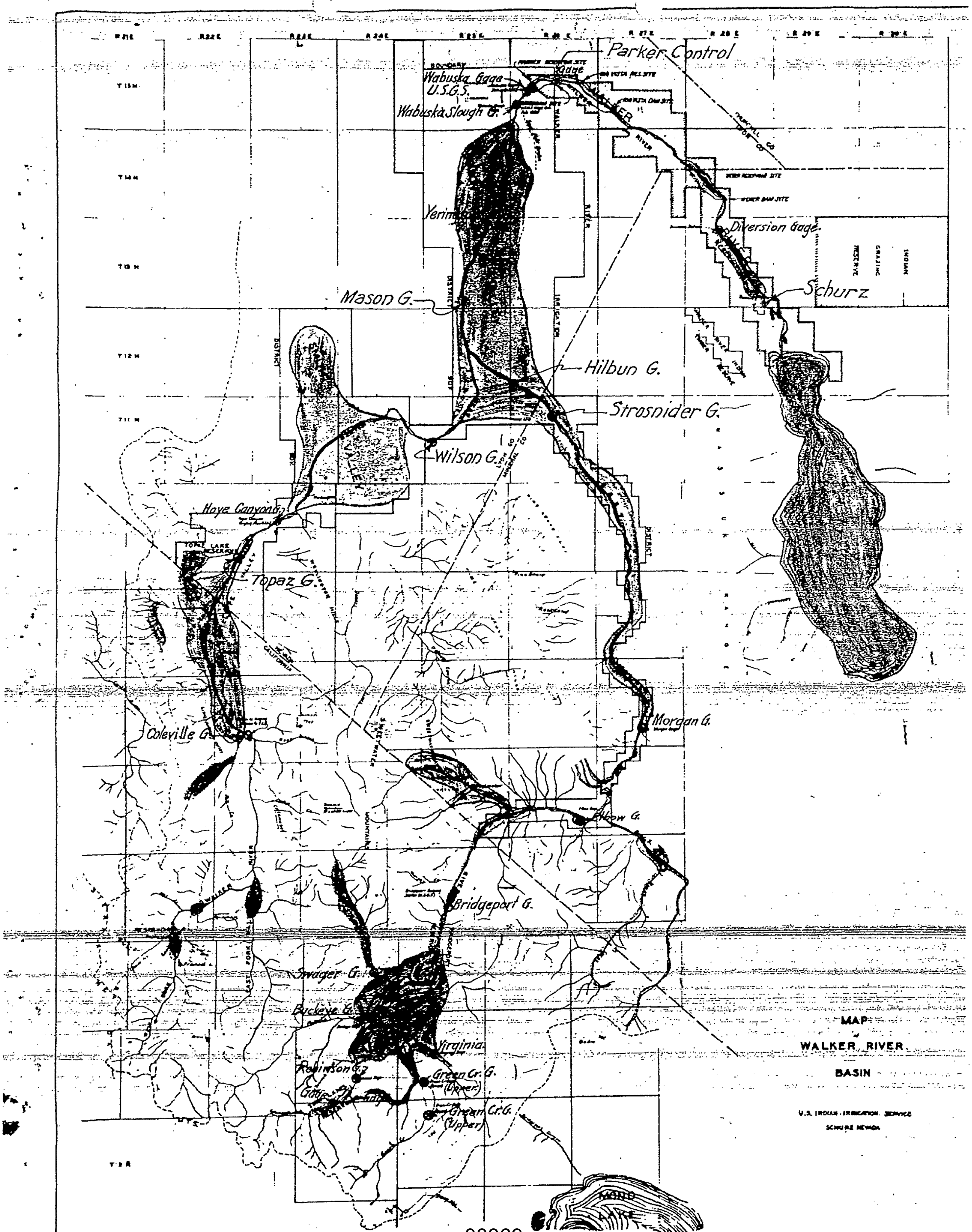
VS

WALKER RIVER IRRIGATION DISTRICT

ET AL

DECEMBER [illegible] 1929


Parker Control
Wabuska Gage U.S.G.S.
Wabuska Slough G.
Yerin
Mason G.
Diversion Gage
Schurz
Hilbun G.
Strosnider G.
Wilson G.
Hoye Canyon G.
Topaz G.
Coleville G.
Morgan G.
Bridgeport G.
Swager G.
Buckeye G.
Virginia
Robinson G.
Green Cr. G. (Lower)
Green Cr. G. (Upper)
MONO LAKE
MAP of WALKER RIVER BASIN
U.S. INDIAN IRRIGATION SERVICE
SCHURZ NEVADA


Parker Control
Gage
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SCHURZ NEVADA

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J. C. STEVENS
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SPALDING BUILDING
PORTLAND, OREGON

L-623 December 1, 1929

RECEIVED FEB 5 1930

Cole L. Harwood
Special Assistant to the Attorney General
Reno, Nevada

Dear Sir:

I submit below the result of my study on the water supply of Walker River in its relation to the irrigation of lands in the Walker River Indian Reservation.

This report has been prepared from a personal examination of the watershed and information and data gathered in April and May 1915 and again in October 1929. The work in 1915 resulted in a report to the U. S. Reclamation Service entitled, "Report on Walker River Irrigation Project, Nevada," dated June 1915.

I spent the time from October 19 to 24, 1929, inclusive, in a trip over the Walker River system in company with E. W. Kronquist and in a general study of stream flow data gathered in recent years and a perusal and discussions of testimony so far taken in the case of United States vs. Walker River Irrigation District, et al.

The field work in October 1929 consisted of an examination of the flow measuring stations on Walker River and its tributaries, the data from which are being used in the case. I also examined the proposed Rio Vista reservoir site and the lands and irrigation system of the Indian Reservation.

I also went over the stream flow data secured by Mr. Kronquist during the past summer, his method of assembly and computations; and convinced myself that these data were prepared in accordance with accepted engineering methods and are sufficiently accurate for all practical purposes.

INDIAN RESERVATION LANDS

In my report of 1915 (p. 14) I stated that there are 24,300 irrigable acres in and bordering the reservation; that ditches then constructed cover 6000 acres and that 1906 acres had been decreed a water right. Mr. Kronquist in his testimony (p. 67) gives 3600 acres under present ditches without extensions and 7800 acres possible under extensions of present system. He also gave the area irrigated in 1920 as 1520 acres (p. 88). This represents very approximately the present status of irrigation in the reservation.

There is more land susceptable of irrigation in the Walker River basin than the available water will supply. In determining the area practicable of irrigation with the available supply, the area in the reservation was placed at 10,700 acres (Report 1915 p. 71). No special study was made at that time of the reservation lands or of storage on the reservation. They were merely included as a part of a broad preliminary plan of reclamation for the entire Walker River system.

The government is seeking water for only 10,000 acres in the reservation - less than half the irrigable area. My recent examination confirms my former belief that there are under the present ditches and practicable extensions thereof, and in the Campbell valley above, 10,000 acres of good land susceptible of practical irrigation in the reservation.

DUTY OF WATER

In my report of 1915 a diversion duty of 3 ft. in depth per season was adopted as an average for the entire Walker River basin. No attempt was made to classify the lands or fix duties for particular areas. Some of the irrigable lands may require only 2 ft. and some 4 or 5, but the average of 3 ft. is still believed to be valid. Actual diversions for all District lands have been 3.12 ft. with a net consumption of 2.68 ft. (Beemer p. 939).

For the reservation lands a quantity of water greater than the average is required, on account of their sandy nature. The subjugation of new sandy lands requires large quantities of water in the early years which however is gradually reduced as the lands become well cropped until a fairly constant quantity is reached, below which it is impracticable to go. Table 1 gives a summary of water used on 24 projects of the U. S. Bureau of Reclamation. The depths are those at the farm borders and do not include seepage or waste from the distribution systems. These data are taken from "Use of Water on Federal Irrigation Projects," by E. B. Debler, Proc. Am. Soc. C. E. March 1929, p. 751.

TABLE 1

FEDERAL IRRIGATION PROJECTS 1912 TO 1926 INC.

Project	Soil	Average Area Irrigated	Average Depth on Farms
1 Belle Fourche	Heavy	45,164 acres	1.22 feet
2 Boise	light	145,616	3.60
3 Carlsbad	medium	22,535	2.36
4 Grandvalley	heavy	10,139	3.61
5 Huntley	heavy	19,406	1.39
6 King Hill	very light	6,460	7.01
7 Klamath	medium	43,325	1.43
8 Lower Yellowstone	heavy	17,540	1.34
9 Milk River	heavy	16,793	0.65
10 South Minidoka	medium	44,945	2.54
11 Newlands (Carson)	medium	38,808	2.88
12 North Platte	medium	107,694	2.23
13 Okanogan	light	5,260	2.60
14 Orland	light	14,554	3.17
15 Rio Grande	medium	96,847	2.89
16 Shoshone (Frannie)	heavy	7,963	2.19
17 Shoshone (Garland)	medium	32,380	2.38
18 Sun River (Shaw)	heavy	7,650	1.54
19 Sun River (Greenfields)	medium	9,867	1.28
20 Umatilla	light	10,970	5.02
21 Uncompahgre	medium	61,178	5.76
22 Yakima (Sunnyside)	medium	91,726	3.29
23 Yakima (Tieton)	light	27,607	2.51
24 Yuma	medium	51,850	3.01
		936,377	2.85

Of particular interest are the data from the Umatilla Project in Oregon, the soils of which are very sandy, somewhat wind-blown, and similar in many respects to those of the reservation. Table 2 shows how the early consumption was gradually lowered as the lands became subjugated. The average rainfall during the season, March to October, incl., was 4.2 inches and during the entire year 9.0 inches.

TABLE 2

UMATILLA PROJECT, OREGON, USE OF WATER

Year	Area Irrigated	Depth applied to land	Percent of total diversions losses	waste	delivered
1912	4600	8.25 ft.	28	2	70
1913	5006	8.45	27	2	71
1914	5100	7.11	40	2	58
1915	5306	5.57	44	28	28
1916	5477	5.76	36	8	56
1917	7327	6.19	25	23	52
1918	9100	5.29	32	16	52
1919	10533	5.24	33	23	44
1920	12028	4.21	31	25	44
1921	13145	4.37	31	24	45
1922	13273	4.47	34	18	48
1923	13330	4.64	32	19	49
1924	13134	4.52	36	12	52
1925	13345	5.53	28	12	60
1926	12549	5.26	28	8	64
1927	11462	5.70	24	16	60
Average	10970	5.02	32	18	50

On the 24 projects listed, irrigating an average total of 936,000 acres, the deliveries to farms averaged 50%, waste 17%, and distribution system losses 33% of the diversions. That is, for the average acre irrigated there was diverted 5.7 acre-feet, of which 2.85 acre-feet was delivered to farms, 0.96 acre-foot was wasted in the processes of operation, and 1.89 acre-feet was lost by seepage in the canal and lateral systems.

The monthly distribution of use throughout the irrigation season is also of interest. Table 3 shows the use on a few projects, to which has been appended various estimated requirements for the Walker River district and reservation lands.

TABLE 3

MONTHLY DISTRIBUTION OF IRRIGATION WATER

DELIVERED TO LANDS

Project		March	April	May	June	July	Aug.	Sept.	Oct.	Total
Newlands	ft.	.03	.28	.58	.53	.64	.46	.28	.08	2.88
	%	1	10	20	18	22	16	10	3	100
Umatilla	ft.	-	.54	.98	.96	1.07	.96	.44	.07	5.02
	%	-	11	20	19	21	19	9	1	100
Sunny-side	ft.	-	.34	.59	.57	.62	.60	.39	.18	3.29
	%	-	10	18	17	19	18	12	6	100
Orland	ft.	.14	.27	.54	.57	.63	.57	.40	.05	3.17
	%	4	9	17	18	20	18	13	1	100
Walker River District, reports by										
Palmer	ft.	-	.21	.47	.62	.67	.47	.16		2.60
	%	-	8	18	24	26	18	6		100
Stevens	ft.	-	.2	.36	.44	.44	.40	.16		2.00
	%	-	10	18	22	22	20	8		100
Indian Reservation Lands, reports by										
Blomgren	ft.	-	.20	.40	.75	.90	.60	.15		3.00
	%	-	7	13	25	30	20	5		100
Kron-quist	ft.	.09	.21	.39	.90	.81	.51	.09		3.00
	%	3	7	13	30	27	17	3		100

It would appear from the foregoing data that the Department's demand of 3 acre-feet per acre on the reservation lands, with an additional 1.5 acre-feet allowed for distribution losses, is a modest one. My own belief is that the bottom lands can probably be irrigated with a less amount, say, 2 acre-feet, but the sandy bench lands will require considerably more, on some tracts as much as 5 or 6 acre-feet per acre. I am however in doubt as to the necessity of such large proportions of the total in mid-summer. The 30% for the maximum month recommended by Blomgren and Kronquist is greatly in excess of that actually used on neighboring projects.

I am inclined to favor my former recommendations, as they are more in conformity with actual use under comparable circumstances. Following is a comparison of use I would recommend with that recommended by Kronquist, showing total acre-feet and flow required at the diversion points.

Month	Stevens			Kronquist		
	%	ac.-ft.	sec.-ft.	%	acre-ft.	sec.-ft.
April	10	4500	75	10	4500	75
May	18	8100	130	13	6000	97
June	22	9900	165	30	13500	225
July	22	9900	160	27	12000	194
August	20	9000	145	17	7500	121
September	8	3600	60	3	1500	25
	100	45,000		100	45,000	

As a practical matter, the actual use depends largely on the supply. If experience should show that 225 sec.-ft. were required in mid-summer for these lands, there would be no objection whatever to diverting that quantity if available. I think it would be good engineering to provide canal capacity for such an amount. However I should hesitate to deprive other lands above in order to provide more than the maximum of 165 sec.-ft. shown in my schedule.

WATER SUPPLY

The next point of inquiry is whether it is a practicable thing to supply 10,000 acres in the reservation with the quantities shown in my schedule above. Are the characteristics of this river system such that taking water from up-river lands, even with subsequent priorities, would not result in securing an adequate supply for the reservation lands? In other words, should up-river lands be deprived of water with no commensurate benefit to the reservation lands?

If transmission losses are excessive, it would hardly appear equitable to deprive up-river lands of an exhorbitant amount of water to provide a small supply at the reservoir, regardless of the legal right to do so. On the other hand, if transmission losses are normal and the reservation lands have the prior right, it would appear just and equitable to recognize that priority and regulate up-river diversions accordingly. What are normal and what are excessive transmission losses?

The answer to these inquiries is not to be found in the opinion of any one man, but rather in actual records of stream flow, diversions, seepage, evaporation, return flow, in all their complexities.

As before stated, the actual use depends largely on the supply. In abundant years there is no complaint and priorities are disregarded. In lean years, all use must be curtailed and priorities become of paramount importance.

Table 4 gives the flow of East Walker above diversions in Mason Valley and of West Walker above Antelope Valley, and their combined flow. There is also shown the departure in percent from the mean. Notice that the past 7 years have, with one exception, been substantially below the mean for the 27 year period. The 6th column shows the cyclic variaations, each figure being the average of the preceding 5 years. The figures in the 6th column have been plotted in Fig. 1. The persistent decline is most pronounced. The question arises whether or not the early records are in error. Stream flow is primarily caused by precipitation although the corespondence is never very well marked. On Fig. 1 is also shown the cyclic variation in precipitation at Reno for the same period averaged by 5-year groups in the same manner as for stream flow. The scales of the two curves are not comparable but the relative decline of the stream flow curve follows broadly that of the precipitation curve. The stream flow records are believed to be substantially correct.

With the development in this valley the decline in water supply since 1918 readily explains the increasing conflict of interest in water rights. If storage had not been provided on this stream, the situation would have been much more critical.

TABLE 4

WALKER RIVER SUPPLY - THOUSANDS OF ACRE-FEET

CLIMATIC YEAR OCTOBER 1 TO SEPTEMBER 30

Year	Above diversions in Antelope Valley	Above diversions in Mason Valley	Total	Departure from mean	Cyclic Stream Flow	Variation precip. Reno
1902-3	226	110	336	-8%	336	8.0
3-4	265	160	425	+17	380	8.3
4-5	176	82	258	-29	340	8.0
5-6	417	220	637	+75	414	7.4
6-7	483	279	762	+110	484	8.5
7-8	185	89	274	-24	471	8.8
8-9	289	153	442	+22	474	8.4
9-10	242	130	372	+2	497	8.5
1910-11	290	269	559	+54	482	9.4
11-12	160	77	237	-35	376	8.2
12-13	153	85	238	-34	370	8.0
13-14	310	272	582	+60	398	9.0
14-15	200	255	455	+25	414	8.5
15-16	250	147	397	+9	382	7.9
16-17	226	64	390	+7	412	8.2
17-18	192	46	338	-7	432	8.4
18-19	183	132	315	-13	379	7.5
19-20	171	103	274	-25	343	8.1
1920-21	225	135	360	-1	335	7.4
21-22	266	165	431	+18	344	8.1
22-23	221	106	327	-10	341	8.6
23-24	68	44	112	-69	301	7.6
24-25	200	120	320	-12	303	7.7
25-26	128	75	203	-44	278	7.2
26-27	236	140	376	+3	268	7.0
27-28	138	90	228	-37	248	6.1
1928-29	109	60	168	-54	259	6.6
Mean	222	141	363	0		

WATER CONSUMPTION

Mr. Beemer has already given certain data regarding the consumption of water in Antelope Valley, after making corrections for evaporation and hold-over storage in Topaz reservoir, as follows. His data are for the entire climatic year, the irrigation season not being segregated.

	Year	Consumption	Consumption per acre
Oct. to Sept.	1923-24	10,900 ac.-ft.	0.7
	1924-25	18,000	1.2
	1925-26	25,600	1.7
	1926-27	36,200	2.4
	1927-28	23,300	1.6

The last column above was added by me based on 15,000 acres under ditch.

Table 5 has been prepared to show the total consumption on East Walker, West Walker and the main stream for the three years of complete records. Results for the irrigation season have been segregated. Consumption as here used means use and waste. It is the difference between inflow and outflow in the several valleys and includes all losses from evaporation, transportation, plant growth, deep seepage, etc. No correction was made for hold-over storage, as the data are not in hand. If the hold-over storage is approximately the same at the end of each season, it may be neglected, but whatever it was it is included in "Consumption". The acres given are merely those nominally under ditch and do not include tributary areas.

TABLE 5

WATER CONSUMPTION IN WALKER RIVER VALLEYS IN ACRE-FEET

Section	1921-22 Oct.- March	April- Sept.	Year	1922-23 Oct.- March	April- Sept.	Year	1923-24 Oct.- March	April- Sept.	Yea
East Walker									
Dam	----	128690	----	40600	73380	119980	29560	13410	429
Strosnider	----	121370	----	43430	62640	105870	34800	9300	441
Consumption	----	7320	----	-2830	10940	8110?	-5240	4110	-11
" in % of supply	--	5.7	--	-6.9	14.8	6.8	-17.8	30.5	-2.
Acres	----	3400	----	3400	3400	----		3400	
Consp. per acre		2.2			3.1			1.2	
West Walker									
Coleville	19060	247390	266450	27300	193940	221240	19770	48130	679
Wilson	12230	192760	204990	26840	137900	164740	19330	35310	546
Consumption	6830	54630	61460	460	56040	56500	440	12820	132
" in % of supply	35.8	22.0	22.9	1.7	28.9	25.5	2.2	26.6	19.
Acres		23000			23000			23000	
Consp. per acre		2.4			2.5			0.56	
Main Walker									
Strosnider & Wilson	38090	332130	370220	70270	200340	270610	54130	44610	987
Parker	28940	218970	247910	52290	78550	130840	51210	1390	526
Consumption	9150	113160	122310	17980	121790	139770	2910	43220	461
" in % of supply	24.0	34.0	33.0	25.6	60.7	51.8	5.2	97.5	47.
Acres		50000			50000			50000	
Consp. per acre		2.3			2.4			0.86	
Parker	28940	218970	247910	52290	78550	130840	51210	1390	526
Schurz	19460	200250	219710	49560	55700	105260	48750	520	492
Consumption	9480	18790	28200	2730	22850	25580	2460	870	37
" in % of supply	32.7	8.6	11.4	5.2	29.0	19.7	4.8	62.4	6.4

The locations of the measuring stations are shown on the accompanying map. The data for East Walker include the long strip from Bridgeport dam to above all diversions for Mason Valley. West Walker data include Antelope and Smith Valleys. Main Walker data are for Mason Valley and also for the reservation.

During the irrigation season the consumption on East Walker ranged from 6 to 30% of the supply. In Antelope and Smith valleys it averaged 26%. In Mason Valley the average was 64%, and on the reservation 33%. An important point is that the consumption percentage increases as the supply diminishes. Thus we have in round figures:

Irrigation season	1922	1923	1924
On East Walker			
Supply ac.-ft.	129,000	73,000	13,000
% consumed	6	15	31
In Antelope and Smith Valleys			
Supply ac.-ft.	247,000	194,000	48,000
% consumed	22	29	*27
In Mason Valley			
Supply ac.-ft.	332,000	200,000	45,000
% consumed	34	61	98
In the Reservation			
Supply ac.-ft.	219,000	78,000	1,400
% consumed	9	29	62

*The data above for Smith Valley consumption requires a correction for storage in Topaz reservoir. The consumption will appear high while water is being stored and low while it is being released. Smith Valley uses some of the stored water which does not appear in the Coleville supply. Mr. Beemer states that 10,000 acre-feet were held over from 1923 to 1924. (cont'd next page)

The consumption is approximately a fixed quantity as long as the supply is ample, but becomes nearly equal to the supply when the latter falls below that fixed amount. On the East Walker the fixed consumption is about 9000 acre-feet; in Antelope and Smith valleys about 55,000; in Mason Valley 120,000, and in the reservation 20,000 acre-feet. These quantities were available in 1922 and 1923 but not in 1924.

The data gathered by Mr. Kronquist during the past summer in the vicinity of Bridgeport enable us to determine the consumption in that valley. All the streams flowing into the valley were measured. The outflow below the dam was also measured and the levels of the reservoir noted. The records begin June 20 and end September 20. They have been grouped in tri-monthly periods and are given in Table 6 below.

TABLE 6

CONSUMPTION IN BRIDGEPORT VALLEY IN ACRE-FEET

Period 1929		Inflow	Outflow (meas.)	Storage Release	Evaporation	Outflow (net)	Consumption (net)
June	20-30	7600	3530	600	120	3050	4550
July	1-10	6320	4600	1300	140	3440	2880
	11-20	3820	4120	2400	140	1860	1960
	21-31	4300	3720	1800	110	2030	2270
Aug.	1-10	2780	3470	1600	90	1960	820
	11-20	3210	3720	1800	70	1990	1220
	21-31	2340	3650	2100	30	1580	760
Sept.	1-10	1270	1600	400	10	1210	60
	11-20	1070	820	0	0	820	250
	21-30	860	810	0	0	810	50
Total		33,570	30,040	12,000	710	18,750	14,820

Adding this amount to the supply, the consumption becomes 40%, including evaporation from the reservoir. Released water from this reservoir is to be treated as a tributary supply coming in between Antelope and Smith valleys.

The figures in the last column are a little erratic due in part to the unknown effect of bank storage in the reservoir and to the inability to compute the volume released from the reservoir with consistent accuracy.

The table shows a consumption of nearly 15,000 acre-feet during the 103 days of record. If the same rate obtained during April and May also, the consumption would amount to 40,000 acre-feet or about 2 feet in depth in the ordinary year over the area under ditches in the valley. Fig 2 (A) shows the accrued inflow and net outflow, the difference being the accrued consumption. Each point on the curves is the sum of the preceding quantities. The consumption was 44% of the supply during the period of record.

TRANSPORTATION LOSSES

Determining the amount of water lost from the river channel in transit is a complex problem and can only be ascertained for particular stretches that are not complicated by diversions and return flow. These losses consist of evaporation from the water surface and from the bank soils and seepage into the channel bed. During the past summer data of this nature were secured on East Walker between the Bridgeport dam and Morgan's ranch, and also on the main stream between Parker's ranch and the Indian diversion dam.

On the East Walker the stations at the outlet of Bridgeport Reservoir, Elbow and Morgan's ranch were used. The distances between them are approximately 13 miles in each case. The tributary flow between the dam and Elbow was not measured, but most of the water was diverted for irrigation from which there was some return flow. Between Elbow and Morgan however the diversions and tributary flow are practically negligible. The river channel throughout this stretch is of sand, gravel and boulders, with well defined banks and water generally covering the entire bed.

Table 7 shows for tri-monthly periods the results obtained.

TABLE 7

LOSSES BRIDGEPORT DAM TO MORGAN'S RANCH IN ACRE-FEET

Period 1929		Dam Mi. 0.0	Elbow Mi. 13	Morgan Mi. 26	Loss and Gain (-) 0 to 13	13 to 26	0 to 26
July	11-20	4120	---	3790	---	---	330
	21-31	3720	---		---	---	560
Aug.	1-10	3470	3040	2900	430	140	570
	11-20	3720	3420	3320	300	100	400
	21-31	3650	3150	3110	500	40	540
Sept.	1-10	1600	1260	1400	340	-140	200
	11-20	820	640	720	180	- 80	100
	21-30	810	700	740	110	- 40	70
Total		21910	12210	19140	1860	20	2770
Loss in percent of supply					13.2	1.6	12.6

Whatever loss existed between Elbow and Morgan was offset by gains from sources that could not have been measured. There was practically no tributary flow during this period. This stretch was not complicated by tributaries, diversions or return flow and showed less than 2% loss. The loss of 13% between the dam and Elbow was due to irrigation along the river and its tributaries. If we could add the flow of Sweetwater and other tributaries above all diversions on them, the loss would be increased by the amounts so measured and would appear as consumption.

The total loss from the dam to Morgan was less than 13% of the measured supply and is to be considered more in the nature of irrigation consumption than a transportation loss.

The figures shown in the first three columns of Table 7 have been added progressively and are shown in Fig. 2 (B) as accrued flow and losses.

From the Yerington weir, below the last diversion in Mason Valley, to the diversion dam for the reservation canals, is a stretch of 33.8 miles. Measuring stations were maintained by Mr. Kronquist as follows:

Below Yerington weir	mile	0.00
Wabuska slough		10.6
Parker control		14.2
Diversion dam		33.8

The District's East side Drainage canal supplies water at mile 11.7 between Wabuska slough and Parker. A number of canals head at the Yerington weir. From this point to the Parker control therefore considerable return water is in evidence. At the Parker control there is a rocky reef and an artificial control. It is believed that most of the subsurface flow appears at the surface at the Parker control and is measured at the station. The channel throughout averages 200 ft. in width with banks 3 to 5' ft. high During periods of low flow the water meanders in a narrow stream within the wider river bed.

Table 8 gives the results obtained in this stretch for tri-monthly periods.

TABLE 8

GAINS AND LOSSES, YERINGTON WEIR TO RESERVATION DIVERSION DAM

IN ACRE-FEET

Period 1929		Weir Mi.0	Slough Mi.10.6	Parker Mi.14.2	Reserv. Mi.33.8	Gain 0to14.2		Loss 14.2to33.8
June	11-20	73	355	693	561	620	31	132
	21-30	89	292	520	378	431	22	142
July	1-10	206	391	582	267	376	19	315
	11-20	378	531	788	640	410	20	148
	21-31	291	392	574	359	283	14	215
Aug.	1-10	0	56	237	96	237	12	141
	11-20	76	87	202	45	126	6	157
	21-31	13	33	198	58	185	9	140
Sept.	1-10	5	16	169	27	164	5	142
	11-20	3	16	122	74	119	5	48
	21-31	0	20	104	78	104	5	26
Total		1134	2189	4189	2583	3055		1606
	s-f.	5.1	4.8	13.5	11.5	13.6		7.2

The gain from the weir to the slough was 1055 acre-feet. From the slough to Parker 2000 acre-feet more was added which came largely from the drainage canal.

In the 19.6 mile stretch from the Parker control to the diversion dam for the reservation canals, the total loss was 1606 acre-feet or 38.4% of the supply. In this stretch there are no diversions and probably no return flow. It is the only stretch where the transportation losses may be measured without complications with other factors. The results for this stretch will therefore warrant a careful analysis.

If we assume the same rate of loss obtained throughout the entire stretch of 33.8 miles, the loss from the weir to Parker, 14.2 miles, would amount to 1160 acre-feet. The return flow then over the same stretch amounted to 1160+3055 = 4215 acre-feet. In the entire stretch of 33.8 miles the loss would be 2766 acre-feet, so that the return flow of 4215 acre-feet exceeded the losses by 1449 acre-feet, showing that much of a gain from the weir to the reservation. The total loss of 2766 acre-feet corresponds to an average flow of 7.7 sec-ft. throughout the irrigation season. The results of Table 8 are shown in Fig. 3.

The losses in this stretch of river consist of seepage into the sandy river channel and evaporation from the water surface and marginal soil. It is also complicated by bank storage. When the river is rising, water is stored in the sands bordering the river channel. When the river falls, some of this water appears in the channel again so that one may expect somewhat erratic results for short periods of time. For longer periods these eccentricities gradually disappear.

The evaporation from moist soils has been determined by a number of experiments conducted by the U. S. Department of Agriculture* at Fort Collins, Colodaro, Davis, California, Denver, Colorado, and elsewhere. From the results of these

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* Evaporation from Saturated Soils and River-Bed Sands - by Ralph L. Parshall, Proc. Am. Soc. C. E. April 1929.

experiments it appears that the evaporation from wet soils may be taken at about 80% of that from a free water surface.

The evaporation from a free water surface for the Walker River Basin during the irrigation season may be taken from the Fallon experimental farm* records after reducing them 20% to correct from a land pan to free water surface.

Month	Evaporation	
April	5.0 in.	0.42 ft.
May	6.6	.55
June	7.8	.65
July	8.5	.71
August	7.6	.63
September	5.1	.42
Total		3.38 = 78.5

With a river channel length of 19.6 mi. averaging 200 feet in width, the total exposed area is 470 acres. During periods of low flow the free water surface is probably not over 25% of this area or 120 acres, on which the evaporation would be as above. On the remaining 350 acres the evaporation may be taken as 80% of that from the free surface. The evaporation losses from this stretch of river during the irrigation season is then approximately as follows, in which the exposed area is divided between water and soil in rough proportion to the flow in the normal year.

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* Trans. Am. Soc. C. E. vol. 90 p. 271.

Month	Exposed Area		Evaporation in acre-feet		
	Water	Soil	Water	Soil	Total
April	200	270	84	90	174
May	300	170	165	74	239
June	350	120	226	62	288
July	250	220	178	125	303
August	200	270	126	137	263
September	120	350	50	118	168
			829	606	1435

We may expect evaporation losses to be roughly constant at about 1500 acre-feet in this stretch of river.

Bank storage may be roughly approximated. Consider a 300 foot strip each side of the river channel which becomes saturated. The soil porosity is about 40%. The saturated volume is wedge shaped, say, 4 feet thick at the river banks and zero 300 feet back, or an average of 2 feet thick. The total saturated volume is 2800 acre-feet, of which 1100 acre-feet is water. Some such an amount would appear as a loss when the river channel fills and as a gain when the channel empties.

The loss by seepage into the soil prism below the channel bed is uncertain but some loss from this source undoubtedly exists.

Table 9 shows the loss between the Parker control and the Reservation Diversion dam during the past three irrigation seasons. Records are those of the Wabuska station of the U. G. Geological Survey at mile 12.5 for 1927 and '28, and for the Parker control for 1929. The length of river then is 21.3 miles in 1927 and '28, and 19.6 miles in 1929.

TABLE 9

LOSS IN 20 MILES OF RIVER CHANNEL ABOVE RESERVATION

DIVERSION DAM IN ACRE-FEET

Period		Inflow	Outflow	Loss or Gain (-) acre-feet	Loss or Gain (-) % of Inflow
1927	April	3,070	2,590	480	16
	May	6,950	5,750	1,200	17
	June	41,300	38,600	2,700	6
	July	20,500	17,800	2,700	13
	August	3,910	3,530	380	10
	September	6,310	5,270	1,040	17
	Season	82,040	73,540	8,500	10
1928	April	3,780	3,440	340	9
	May	6,270	4,270	2,000	32
	June	3,910	4,020	-110	-3
	July	1,840	1,430	410	23
	August	2,280	1,800	480	21
	September	600	160	440	73
	Season	18,680	15,120	3,560	19
1929	April	1,400	1,310	90	6
	May	1,850	1,620	230	12
	June	1,870	1,470	400	21
	July	1,940	1,270	670	34
	August	640	200	440	69
	September	400	180	220	55
	Season	8,100	6,050	2,050	25

The records at the Wabuska U. S. G. S. station are not as reliable as those at the Parker control. The calculations made above showing 1500 acre-feet lost by evaporation in this stretch of river appear to be fairly well corroborated by the results of 1928 and '29. Some additional amount should be allowed for seepage. The loss in 1927 can be accounted for in part by bank storage that did not return during the period of record or else was dissipated entirely. If the river channel remained full entirely during June and July the evaporation from an all-water surface in the river and also from a fairly wide strip of land each side of the channel that was kept wet, would be increased. Thus the evaporation losses in times of high flow might easily be two or three times those during periods of low flow. The amount calculated above may be considered the least that may be expected as long as there is sufficient flow to supply it.

Notice the reduction in loss as the flow diminishes, e. g. August 1927, June 1928. These are undoubtedly due to gains from returned bank storage.

The accrued flows from Table 9 are shown in Figs. 4 and 5, from which the relative magnitude of the quantities may be seen better than from the table.

The results of these data indicate that a minimum loss of around 2000 sec.-ft. may be expected from the Parker control to the reservation diversion dam. This would be equivalent to an average flow of less than 6.0 sec.-ft. This loss will be over-balanced by return flow above the Parker control that cannot at present be used elsewhere than on the reservation. If 10,000 acres were being irrigated in the reservation, a total of 45,000 acre-feet would have to be supplied. From such a flow a loss of, say, 5000 acre-feet might be expected, but a return flow of at least this amount could be counted on. It would appear therefore that only the amount required at the reservation dam for 10,000 acres need pass the Yerington weir.

RETURN FLOW

In my report of 1915 some data were presented on return flow from irrigation. In that report the following amounts were used for return flow that might be rediverted and used.

Antelope Valley	50% of diversion	
Smith Valley	35% "	"
Mason Valley from		
West Walker	25% "	"
East and Main	15% "	"

In the later part of the seasons of 1922 and 1923 Mr. Beemer obtained data on return flow in the several valleys of the basin. These are in evidence in the case. In going over this work I found that the results from the key stations of Bridgeport Dam, Strosnider, Coleville and Wilson did not check with the data from these stations published by the U. S. Geological Survey. I assumed that Mr. Beemer's results were prepared from preliminary estimates of flow that were later revised for publication. I have tabulated the results from both sources. The differences are not great and tend to compensate in the final summary.

By return flow is meant the portion of water diverted into ditches that finds its way back to the river. It includes waste from canals, unmeasured tributary flow, or any other unmeasured accretions to river flow.

The procedure followed in determining return flow for a valley is to measure the inflow from the main stream and tributaries, the diversions into canals, and the outflow. The ideal case is where the river flows into and out of a valley in canyons so that measuring stations may be installed above all diversions and below all increments from return flow. Using the following notation, the various factors involved may be formulated as shown.

Let I = Inflow from all sources into the valley

O = Outflow at lower end of valley

D = Sum of all diversions in the valley

R = Return flow

C = Consumption = I-O

The outflow consists of two parts the undiverted inflow and a portion of diversions that finds its way again into the river. Therefore the total inflow is accounted for thus:

$$I = D+(O-R) \quad \ldots\ldots\ldots\ldots (1)$$

whence $$R = D+O-I \quad \ldots\ldots\ldots\ldots (2)$$

or $$R = D-(I-O) \quad \ldots\ldots\ldots\ldots (3)$$

or $$R = O-(I-D) \quad \ldots\ldots\ldots\ldots (4)$$

Mr. Beemer used formula (4) calling (I-D) "theoretical flow," at the lower station. In my 1915 report I used formula (3) calling (I-O) "losses". A happier term for this quantity is "consumption" as used herein, so that

$$R = D-C \quad \ldots\ldots\ldots\ldots (5)$$

in which R may be either positive or negative, according as consumption is less or greater than diversions. Table 10 is a summary of the results secured by Mr.Beemer taken from Exhibit ~~B~~ 17, to which has been added the results from Yerington weir to the Wabuska station of the U. S. Geological Survey, called Parker in the table.

In Table 11 are given the same data except that the published stream flow data at the key stations were used.

(see next page for table)

TABLE 10

RETURN FLOW WALKER RIVER BASIN

Summary in Acre-Feet

Data from Exhibit 17

Section	Inflow a.f.	Diversions a.f.	Diversions % of I	Outflow a.f.	Return Flow a.f.	Return Flow %ofI	Return Flow %ofD
1922 August 1 to September 24 - 55 Days							
East Walker							
Dam to Morgan	16180	4470	28	14240	2530	16	56
Dam to Strosnider	16180	9820	60	13390	7030	43	72
Dam to Hilbun	16180	19730	122	3330	6880	42	35
West Walker							
Coleville to Topaz	17430	18590	107	7580	8740	43	41
Coleville to Wilson	44460	45340	101	15240	16120	36	36
Main Walker							
Junction to Mason	18570	8020	43	12580	2030	11	25
Junction to Parker	18570	20710	112	3540	5680	31	27
Total System							
Above Junction	60640	65070	107	18570	23000	38	35
Above Parker	60640	85780	141	3540	28680	47	33
1923 July 23 to September 10 - 50 Days							
East Walker							
Dam to Morgan	16160	5120	32	13720	2680	17	52
Dam to Strosnider	16160	9850	61	12650	6340	40	65
Dam to Hilbun	16160	20020	124	1450	5310	33	27
West Walker							
Coleville to Topaz	20730	18200	88	10680	8150	39	45
Coleville to Wilson	52830	42950	81	26490	16610	32	30
Main Walker							
Junction to Mason	27940	7520	27	25900	5480	20	73
Junction to Parker	27940	23800	85	8720	4580	16	19
Total System							
Above Junction	68990	62970	91	27940	21920	32	35
Above Parker	68990	86770	126	8720	26500	38	31

TABLE 11

RETURN FLOW WALKER RIVER BASIN

Summary in Acre-Feet

Data from Reports published by U. S. Geological Survey

Section	Inflow a.f.	Diversions a.f.	Diversions % of I	Outflow a.f.	Return Flow a.f.	Return Flow %ofI	Return Flow %ofD
1922 August 1 to September 24 - 55 Days							
East Walker							
Dam to Morgan	16810	4470	29	14240	1900	12	42
Dam to Strosnider	16810	9820	60	13260	6270	39	64
Dam to Hilbun	16810	19730	121	3330	6250	39	32
West Walker							
Coleville to Topaz	17280	18590	107	7580	8890	51	48
Coleville to Wilson	44310	45340	102	16310	17340	39	38
Main Walker							
Junction to Mason	19640	8020	41	12140	520	3	6
Junction to Parker	19640	20710	106	3540	4610	24	22
Total System							
Above Junction	61120	65070	106	19640	23590	39	36
Above Parker	61120	85780	140	3540	28200	46	33
1923 July 23 to September 10 - 50 Days							
East Walker							
Dam to Morgan	16440	5120	33	13720	2400	16	47
Dam to Strosnider	16440	9850	64	11890	5300	34	54
Dam to Hilbun	16440	20020	130	1450	5030	33	25
West Walker							
Coleville to Topaz	21990	18200	83	10680	6890	31	38
Coleville to Wilson	54090	42950	80	25890	14750	27	34
Main Walker							
Junction to Mason	27340	7520	28	25900	6080	22	81
Junction to Parker	27340	23800	87	8720	5180	19	22
Total System							
Above Junction	70530	62970	89	27340	19780	28	31
Above Parker	70530	86770	123	8720	24960	35	29

These tabulations show that during the last 50 days of these two seasons there was diverted into ditches 86,000 acre-feet, of which 1/3 returned to the stream. The total supply averaged 64,000 acre-feet, hence the diversion exceeded the supply about 30 percent, the return water supplying the difference.

These data are incomplete, as they do not cover the entire season. Return flow persists throughout the entire irrigation season and may even extend over most of the year. The most that can be got from these data is the return flow in percent of diversions, as it is probable this rate persists throughout most of the irrigation season at least.

Comparing the results from Table 11 with the estimates made in 1915, we find:

	Estimated in 1915	Measured 1922-23
Antelope Valley	50%	49%
Smith Valley	35	32
Mason Valley	about 20	22

In Smith Valley the diversions were 26,750 acre-feet, of which 8450 were returned in 1922. In 1923 the corresponding figures were 24750 and 7860, giving 32% returned. In Mason Valley, Junction to Parker, the diversions and return waters were respectively 20,710 and 4610 acre-feet in 1922 and 27,340 and 5180 in 1923, or 22%.

The point may be raised as to the effect of stored water, since the district could perhaps claim all the return flow from storage. It is impossible to tag the stored water, but a rough analysis can be made. Using Table 10 for 1922:

Released from reservoir 44,460-17,430 =	27,030 ac.-ft.
Add outflow at Topaz	7,580
Inflow for Smith Valley	34,610

of which 78% was stored water.

Return flow in Smith Valley 16120-8740=	7,380

which is 22.2% of inflow.

Return from stored water in Smith Valley 22% of 27,030 =	5,750
Inflow to Mason Valley from West Walker	15,240
of which 78% was from storage	11,900
In Mason Valley return flow was 31% of inflow; hence return from stored water in Mason 31% of 11,900	3,690

Summarizing the results for 1922:

		Natural Flow	Stored Water	Total
Return flow	- East Walker	6880	0	6880
	- Antelope Valley	8740	0	8740
	- Smith Valley	1630	5750	7380
	- Mason Valley	1990	3690	5680
	Total	19,240	9440	28,680

A similar calculation for 1923 shows:

Released from reservoir 52,830-20,730 =	32,100 ac.-ft.
Outflow at Topaz	10,680
Inflow to Smith Valley	42,780

of which 75% was stored water.

Return in Smith Valley 16,610-8150 =	8,460

which is 19.8% of inflow.

Return from stored water in Smith Valley 19.8% of 32,100	6,350

Inflow to Mason Valley from West Walker	26,490
of which 75% was from storage	19,800
In Mason Valley return flow was 16% of inflow; hence return from storage water in Mason 16% of 19,800	3,180

Summarizing the results for 1923:

	Natural Flow	Stored Water	Total
Return flow - East Walker	5330	0	5330
- Antelope Valley	8150	0	8150
- Smith Valley	2110	6350	8460
- Mason Valley	1400	3180	4580
Total	16,990	9530	26,520

Combining the two seasons' data, these calculations show that while the supply from Topaz storage was 46% of the total supply, the return flow from that storage was 34% of the total return. If Table 11 had been used, it would show a total supply of 131,650, a total return of 53,160, and a return from stored water of 19,190 acre-feet. The stored water was therefore 45% of the supply and the return from stored water 36% of the total return.

In Fig. 6 are shown the accrued diversions, consumptions and return flows for the several valleys for 1922 and 1923 taken from the tabulations from which Table 10 was compiled.

CONCLUSIONS

The foregoing analysis of the data in hand shows:

1. There are 10,000 acres of choice irrigable land in the Walker River Indian Reservation out of a total possible irrigable area of 24,000 acres.

2. These lands should have a supply of 4.5 acre-feet per acre during the irrigation season, April to September, at the diversion points.

3. Of the seasonal supply about 10,000 acre-feet should be available during the month of maximum use. This corresponds to a flow of nearly 170 sec.-ft.

4. It is entirely practicable to supply this quantity of water to the reservation lands if they have a prior right to the waters of Walker River.

5. Water released from up-river points will reach the reservation lands without excessive losses.

6. The return water below the last diversion in Mason Valley that can not be otherwise used will supply the transportation losses from that point to the reservation.

7. There is no evidence of unusual transportation losses in any portions of the Walker River channels.

8. The total consumption of water on lands of this basin averages 2.4 acre-feet per acre during a normal year.

9. During the past 7 years the supply has gener-

ally been below normal, resulting in acute situations and placing a premium on early priorities.

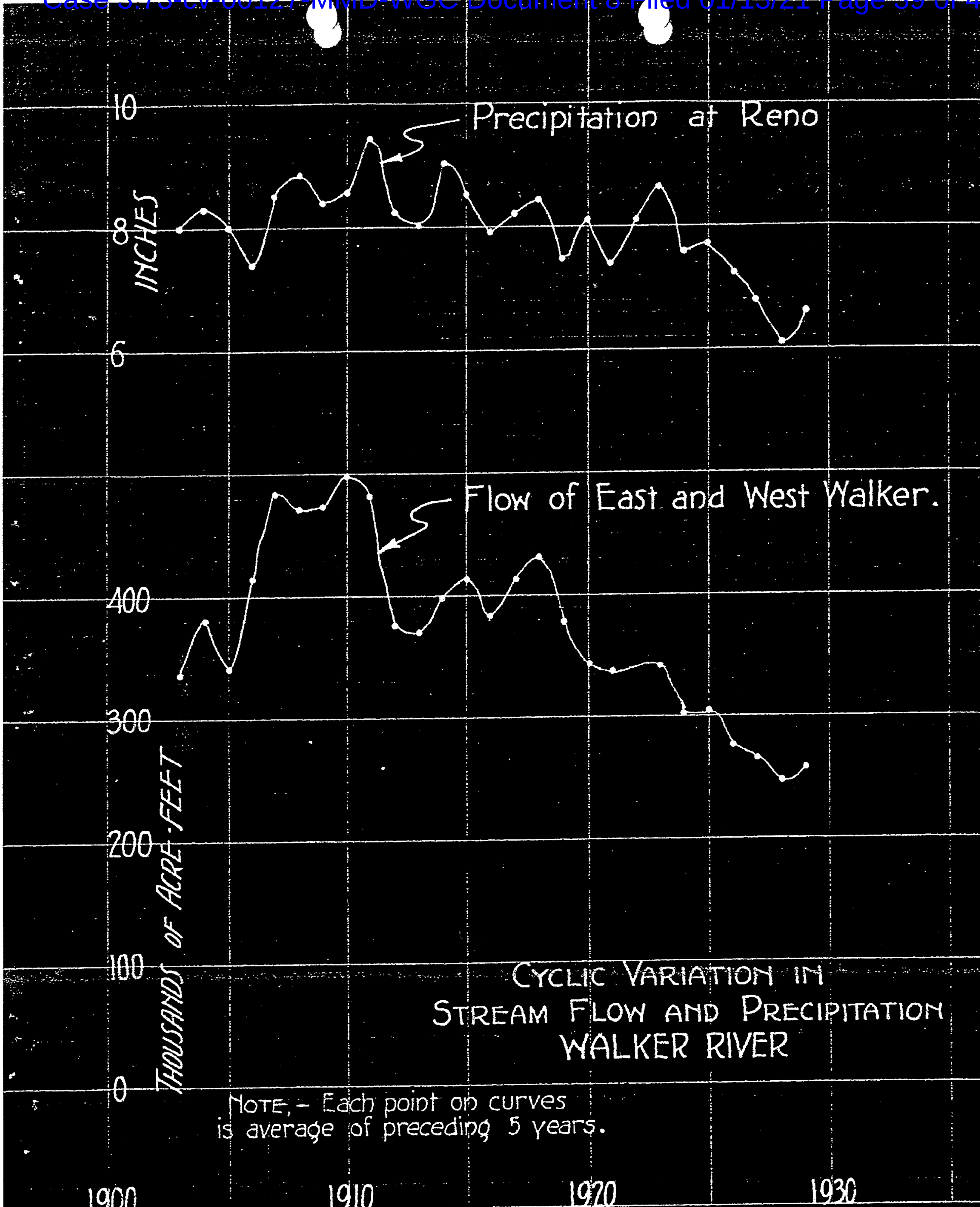
10. Had it not been for the reservoirs already constructed the situation would have been much more critical.

11. The return flow from irrigation is about 1/3 of the diversions in the entire basin.

12. The return flow from water stored in Topaz Reservoir was about 1/3 of the total return during 1922 and 1923. The proportion of return from stored water has increased since the Bridgeport reservoir was placed in service in 1925.

Very truly yours

J C Stevens



Precipitation at Reno
10
8
6
INCHES
Flow of East and West Walker.
400
300
200
100
0
THOUSANDS OF ACRE-FEET
CYCLIC VARIATION IN
STREAM FLOW AND PRECIPITATION
WALKER RIVER
NOTE, - Each point on curves
is average of preceding 5 years.
1900
1910
1920
1930

FIG. I

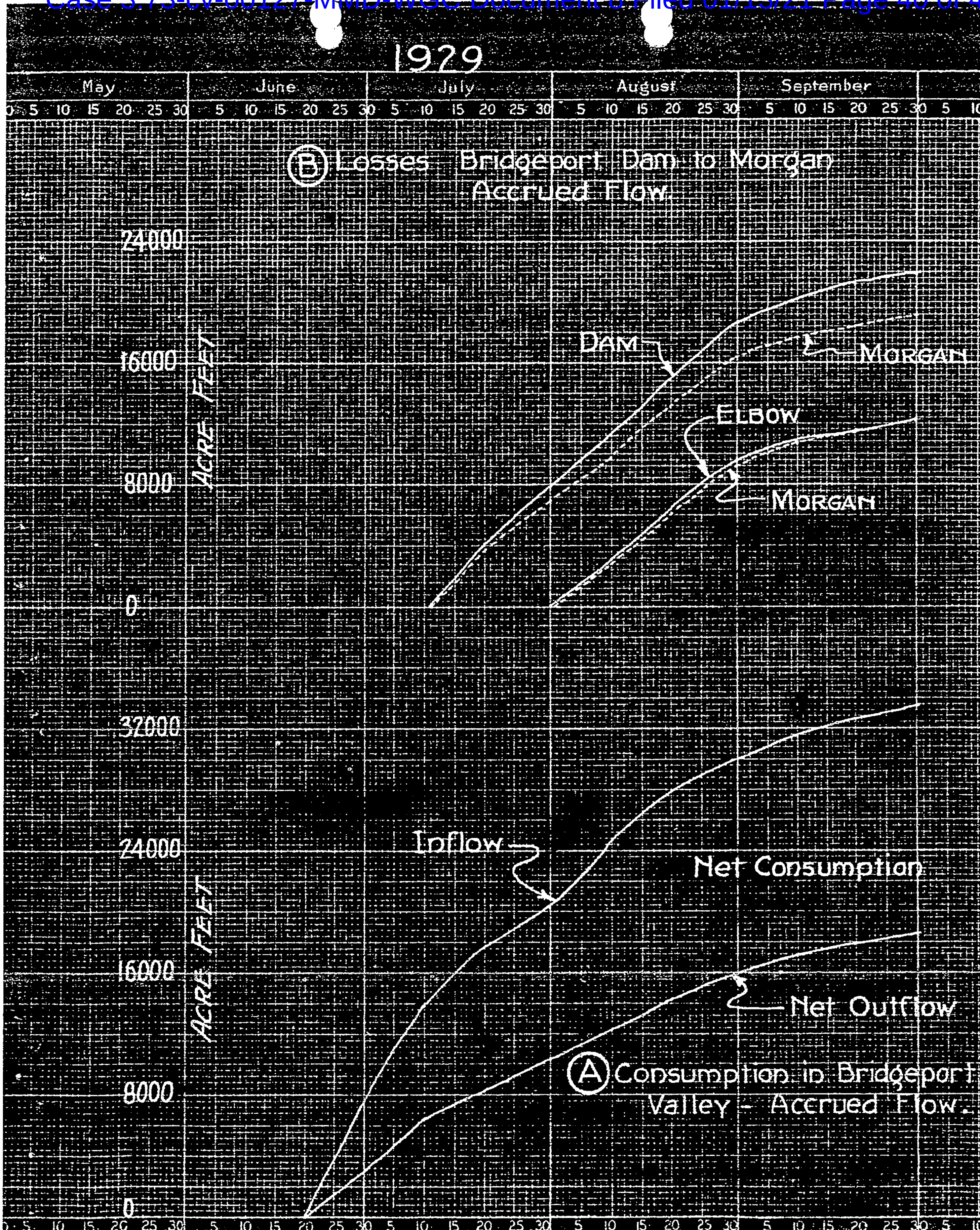

1929
May
June
July
August
September
Ⓑ Losses Bridgeport Dam to Morgan
Accrued Flow.
24000
16000
8000
0
ACRE FEET
DAM
MORGAN
ELBOW
MORGAN
32000
24000
16000
8000
0
ACRE FEET
Inflow
Net Consumption
Net Outflow
Ⓐ Consumption in Bridgeport
Valley - Accrued Flow.

FIG. 2

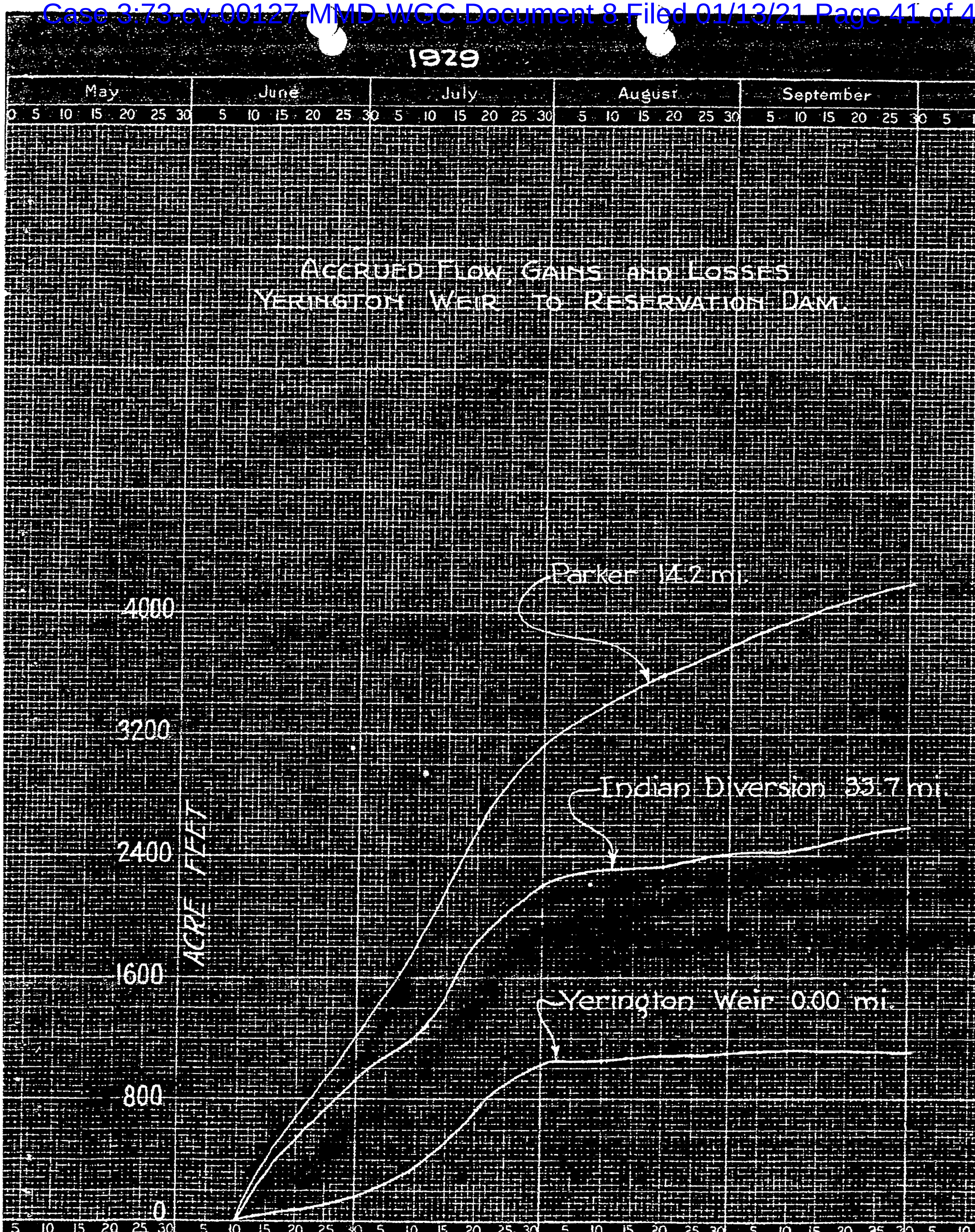

1929
May
June
July
August
September
ACCRUED FLOW, GAINS AND LOSSES
YERINGTON WEIR TO RESERVATION DAM.
Parker 14.2 mi.
Indian Diversion 33.7 mi.
Yerington Weir 0.00 mi.
ACRE FEET
4000
3200
2400
1600
800
0

FIG. 3.

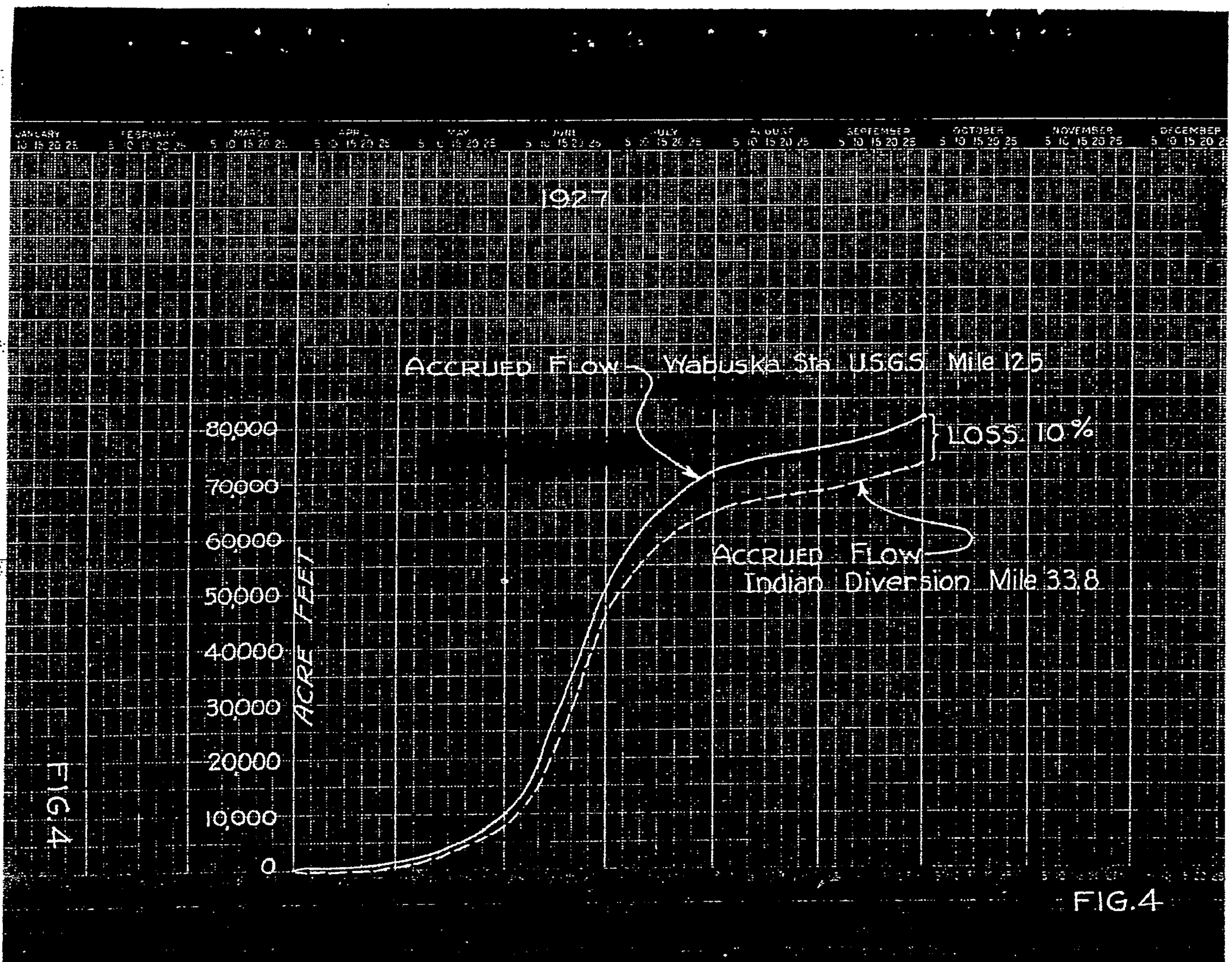
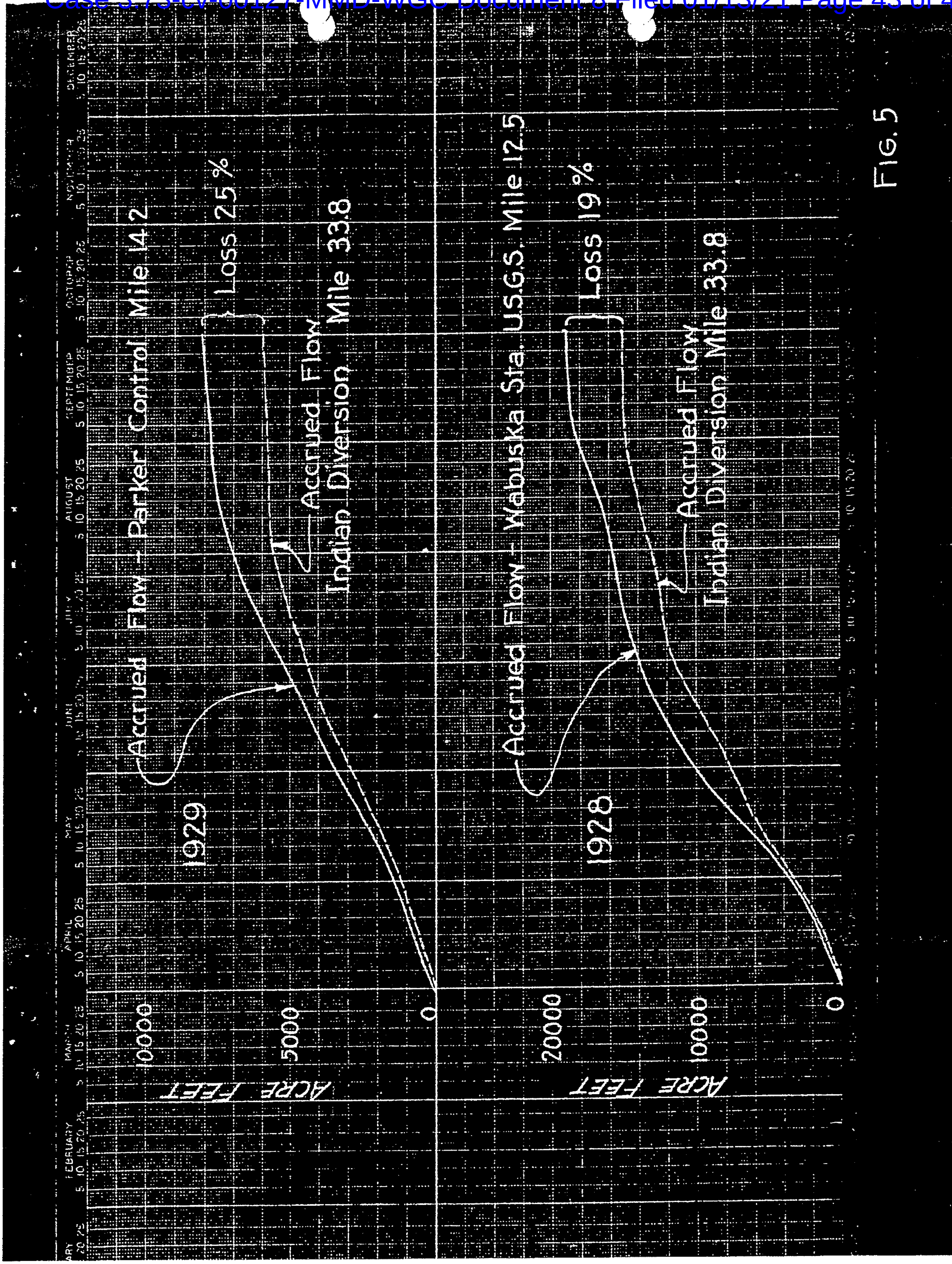

1927
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
5 10 15 20 25
ACRE FEET
0
10,000
20000
30000
40000
50000
60000
70000
80000
ACCRUED FLOW – Wabuska Sta. U.S.G.S. Mile 12.5
ACCRUED FLOW
Indian Diversion Mile 33.8
LOSS 10%

FIG.4


Accrued Flow - Parker Control Mile 14.2
Loss 25 %
Accrued Flow
Indian Diversion Mile 33.8
1929
10000
5000
0
ACRE FEET
Accrued Flow - Wabuska Sta. U.S.G.S. Mile 12.5
Loss 19 %
Accrued Flow
Indian Diversion Mile 33.8
1928
20000
10000
0
ACRE FEET
FIG. 5

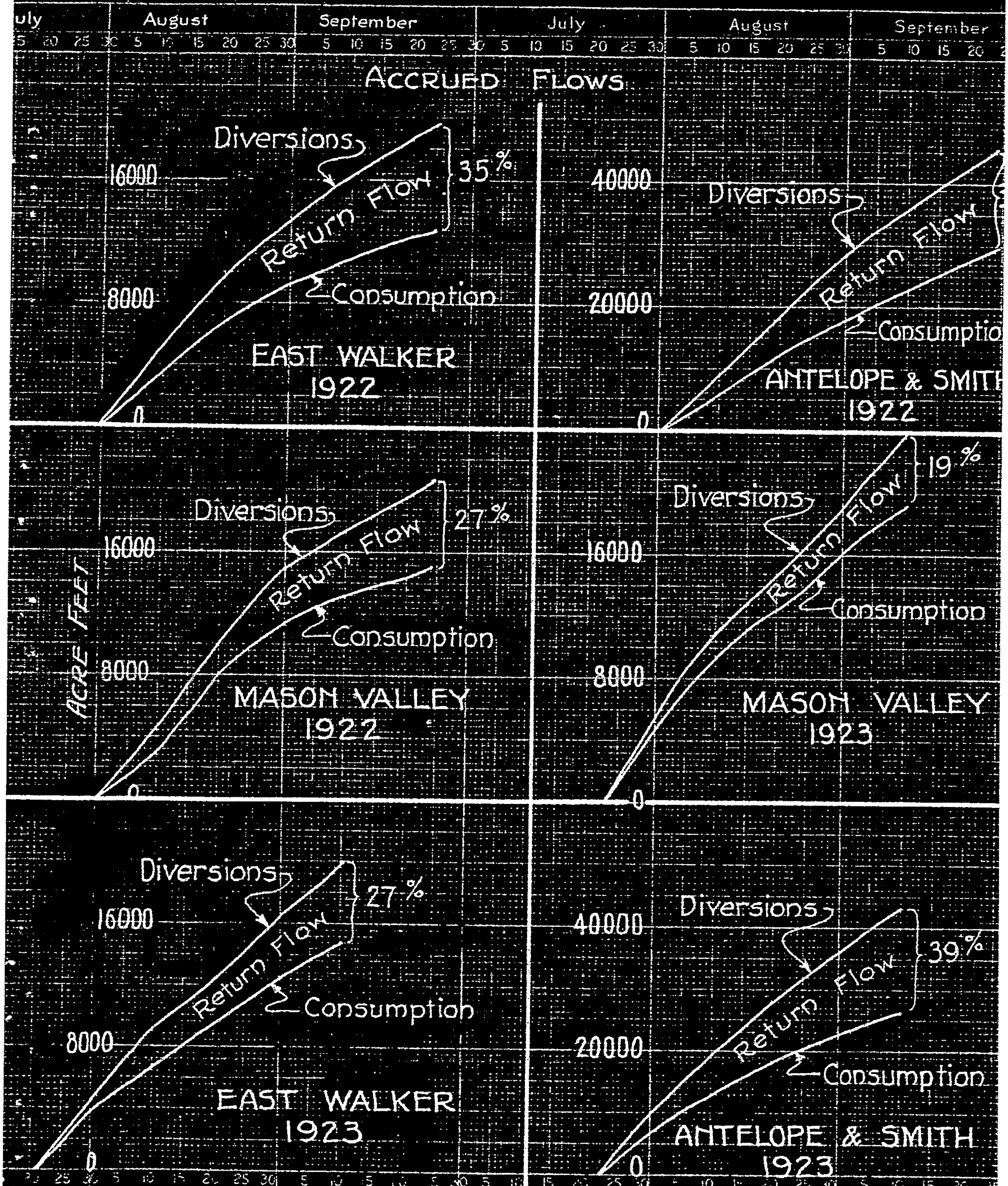

ACCRUED FLOWS
July
August
September
ACRE FEET
Diversions
Return Flow
Consumption
35 %
16000
8000
0
EAST WALKER
1922
40000
20000
ANTELOPE & SMITH
1922
27 %
MASON VALLEY
1922
19 %
MASON VALLEY
1923
EAST WALKER
1923
39 %
ANTELOPE & SMITH
1923

FIG. 6